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Theunis Piersma

## When a year takes 18 months: evidence for a strong circannual clock in a shorebird

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**Abstract** During the last three of 20 years kept as a pet, a red knot (*Calidris canutus*) went through two complete ‘circannual’ cycles of body mass and plumage. With a record cycle length of 18 months, this individual shorebird provides evidence for an exceptionally strong circannual clock system. The absence of synchronisation to outdoor but visible periodic cues suggests that the constant, socially-induced, day-night environment was of overriding importance. So far, only for songbirds is there firm experimental evidence that annual cycles are orchestrated by an endogenous circannual clock system. In constant environments the circannual cycles of these passerines tend to have periods that are shorter, rather than longer, than a year.

### Introduction

Among birds, only for the songbirds (Order Passeriformes) is there firm experimental evidence for an endogenous circannual clock orchestrating annual cycles in plumage, body mass and gonadal development (Gwinner 1986). In constant environments, the circannual cycles of such passerines tend to have periods less than a year. The only nonpasserine species for which experimental data have also suggested the presence of an endogenous circannual clock is the long-distance migrating red knot, *Calidris canutus* (Cadée et al. 1996), a large scolopacid (sandpiper) of the Order Charadriiformes (Piersma et al. 1996). Here I report on a tame red knot that, during the last three of its 20 years of life in captivity, went through

two complete ‘circannual’ cycles of body mass and plumage. Thus, this bird provides evidence of an exceptionally strong circannual clock with a record free-running cycle length of 18 months.

### Material and methods

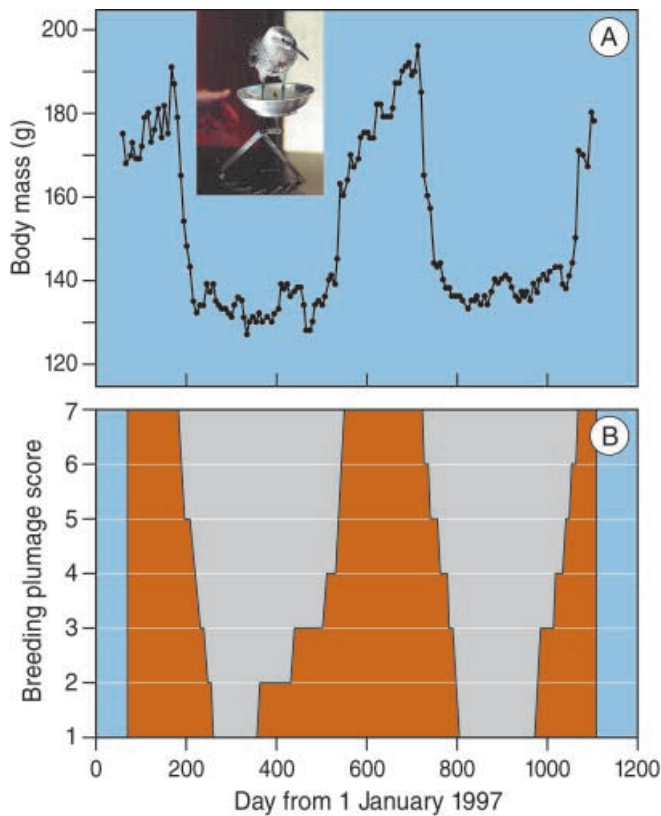
The red knot was found as an adult on the Dutch seashore incapable of flight (left wing broken) in February 1980. Until its death in late January 2000 it was kept under constant conditions in the same house in a coastal village by the same caring couple. During all seasons the daily routine remained the same: getting up at 0600 hours, taking a freshwater bath between 0600 and 0800 hours, often being fed small crushed mussels, *Mytilus edulis*, during the daytime and always minced beef (sold for human consumption) in the morning and again before going to sleep in an open box with clean sand at 2200 hours. In the early afternoon, the bird routinely received a fresh loaf of bread on which it spent 1–2 h probing, probably exercising its sensitive bill tip (Piersma et al. 1998). After the caring couple got in touch with T.P., from 2 March 1997 onwards the bird was weighed each week to the nearest gram on a balance. The extent of the breeding plumage was scored on a 7-point scale, from ‘1’ to indicate the grey winter plumage to ‘7’ to indicate the full red breeding plumage. Quantitative observations continued until 20 January 2000, a few days before its sudden death. Although it probably died of old age, except for a slight eye-infection lasting 2 weeks during its penultimate year of life, the bird had been in good health all the time it had been in captivity. Its behaviour, which included warning its human caretakers of raptors flying over the house, made clear that it had full vision.

### Results

During the three years of observation, the red knot went through two complete mass/plumage cycles (Fig. 1). This included a period of high body mass, a period with a rapid decrease in mass with a complete moult from the rusty-red breeding plumage to the uniformly grey winter plumage, a period of low body mass when the bird was grey, and a period of mass increase during which the plumage changed from grey into rusty-red. Although the periods with high body mass and a rusty-red plumage (indicating preparedness for a northward migration to

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**Fig. 1** Seasonal changes in body mass (A) and the extent of breeding plumage (B) of a red knot kept as a pet between 2 March 1997 (day 61) until 20 January 2000 (day 1106). The inset shows the red knot, named 'Peter', being weighed

high arctic breeding grounds), were not coupled with late spring and early summer as in the wild, the shape of the cycle was similar to those with a length of 12 months shown by red knots in outdoor aviaries in the Netherlands (Piersma et al. 1995). The time between the first and second body mass peak was 547 days, between the first and second steep mass decline 549 days, between the first and second steep mass increase 533 days, between the first and second occurrence of breeding plumage loss (with a plumage score of '4') 549 days, and similarly during the breeding plumage gain, 515 days. These estimates yielded an average cycle length of 539 days, or 18 months.

## Discussion

With a mean life expectancy of 5–6 years and a maximum recorded age of 25 years in the wild (Boyd and Piersma 2001), this study reports sustained circannual

cycles in a very old red knot. Like some of the songbirds studied (Gwinner 1986), free-running circannual rhythms appear to persist throughout life. Although the red knots previously investigated showed evidence of cycles up to 18 months (Cadée et al. 1996; T. Piersma, unpublished data), an endogenously driven cycle length of 18 months is much longer than any of those measured in passerines so far (Gwinner 1986). In this particular case the clock may have been slowed down by old age. Yet, taken together, these observations nevertheless hint at consistent differences between the circannual clocks of different groups of birds.

The experimental conditions were not fully controlled with respect to constancy of visible clues about photoperiodic changes. By looking through the windows of the house, the bird should have been able to register the natural 12-month cycle of shortening and lengthening days. Daily routines, ambient temperatures and food on offer remained very constant throughout the period of observation. Clearly it did not use the outdoor photoperiodic changes to synchronise its own cycle during the 3 years of observation (and, according to its caretakers, not during the previous 17 years either). Thus, under the conditions experienced by the bird, the outdoor light regime was not sufficient to synchronise the circannual rhythm which, as a consequence, free-ran with its own natural period of 18 months.

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